ANNUAL REPORT

June 1991 through July 1992

FLANK SOLAR WIND INTERACTION

NASA Contract NAS5-31216

August 21, 1992

Principal Investigator: Stewart L. Moses

Co-Investigator: Eugene W. Greenstadt

Electromagnetic Systems and Technology Department, TRW

TRW Space and Technology Group
Applied Technology Division
One Space Park
Redondo Beach, CA 90278

(NASA-CR-189285) FLANK SOLAR WIND INTERACTION Annual Report, Jun. 1991 - Jul. 1992 (TRW) 7 p

N93-12303

Unclas

G3/92 0127103

ANNUAL REPORT

FLANK SOLAR WIND INTERACTION

TABLE OF CONTENTS

ANNUAL REPORT

FLANK SOLAR WIND INTERACTION

August 21, 1992

Principal Investigator: Stewart L. Moses

Co-Investigator: Eugene W. Greenstadt

Technical Summary

Introduction

This report summarizes the results of the first 12 months of our program to study the interaction of the Earth's magnetosphere with the solar wind on the far flanks of the bow shock. This study employs data from the ISEE-3 spacecraft during its traversals of the Earth's magnetotail and correlative data from spacecraft monitoring the solar wind upstream.

Our main effort to date has involved assembling data sets and developing new plotting programs. Two talks were given at the Spring Meeting of the American Geophysical Union describing our initial results from analyzing data from the far flank foreshock and magnetosheath. The following sections summarize our results.

Foreshock

The most pressing questions involved with the physics of the foreshock focus on identifying the factors controlling the escape of ions upstream and the subsequent generation of magnetic field turbulence. Numerical simulations have done much to explain the processes generating the turbulence and we are only now beginning to perform detailed comparisons between the simulation results and actual space data (see *Greenstadt et al.* [1991]).

One largely under-utilized diagnostic for studying upstream ions is plasma wave data. Plasma waves are often a much more sensitive indication of the presence of energetic particle populations than direct detection by plasma sensors. This fact is particularly vital when analyzing ISEE-3 data in the tail because of the earlier failure of the plasma ion probe. With the ISEE-3 PWS we can detect the presence of ion populations whose energy density is too small to produce appreciable magnetic field turbulence.

We have found by looking at shock crossings and foreshock entrances on the far flanks that, despite the obvious weakness (low Mach number) of the flank shocks, energetic ions abound and generate levels of plasma wave emissions comparable to what is observed in the foreshock near the subsolar point. Our effort has been to identify the parameters resulting in the presence of these emissions and to develop models for how the ions producing these waves are found where they are.

This is not as simple on the flanks of the bow shock as near the shock nose. On the flanks the bow shock surface falls away steeply and we believe that we have evidence that ions reflected off the shock can stream along the shock surface great distances and influence the foreshock and shock structure far from their point of origin. This effect results in a form of "cross-talk", where the physics of the local shock interaction if affected by particles and turbulence deriving from a location where the shock physics may be entirely different [*Greenstadt et al.*, 1992].

Two parameters have so far been examined for their influence on the presence of upstream turbulence: the shock normal angle, ϑ_{Bn}, and the angle between the magnetic field and the solar wind streaming direction, ϑ_{BX}. The shock normal angle governs the physics of ion reflection intrinsic to the local shock, while ϑ_{BX} appears to gauge the non-local effects. In Figure 1 we have plotted a scatter diagram of the presence or absence of plasma wave turbulence upstream in ϑ_{Bn}-ϑ_{BX} space. In our model we would expect an absence of plasma wave turbulence for simultaneously large values of ϑ_{Bn} and ϑ_{BX}, while combinations of large and small values of either angle should produce plasma wave turbulence. Because the shock normal on the flanks is nearly perpendicular to the solar wind streaming direction of the solar wind it is geometrically impossible to get both angles small at the same time. The scatter in Figure 1 roughly confirms our expectations, but certain exceptions impel us to examine more cases, and we suspect other parameters may also be important.

Magnetosheath

In addition to the unexpectedly large amplitude turbulence observed upstream on the far flanks, ISEE-3 has also detected unexpectely large amplitude turbulence downstream in the flank magnetosheath. What is particularly surprising about this turbulence is its persistence tens to hundreds of R_E downstream of the bow shock. We have also detected the electron plasma oscillations, a typically upstream emission found in the foreshock, great distances downstream of the nearest shock. We are still seeking an explanation for the presence of the plasma oscillations downstream at all.

Our investigation has also led us to examine the downstream emissions at high time resolution. Figure 2 shows an example of the magnetosheath waves found downstream of a flank bow shock crossing with every data point plotted. The extreme spiky-ness of the mid-frequency waves (below 10 kHz) was originally thought to be caused by the spin modulation of the waves by the motion of the dipole antennas. Such a modulation explains the electron plasma oscillations' signature in the 18 kHz channel. The extreme peak-to valley ratios at mid-frequencies (two to three orders of magnitude in amplitude) was thought to result from the wavelengths of the emissions being comparable to the antenna length (90 meters tip-to-tip) [*Fuselier and Gurnett*, 1984; *Gallagher*, 1985].

An examination of the wave polarization, however, has shown that the mid-frequency emissions, unlike the electron plasma oscillations, exhibit no particular polarization and the spiky-ness must therefore be intrinsic temporal variability. The very nature of this emission is very peculiar, with its extreme amplitude variability, lack of polarization, and persistence far beyond all logical sources of free energy, and we will continue to search for explanations for its presence.

Work in Progress

Foreshock

The next task involves assembling more case of the presence or absence of upstream plasma wave emissions. We are aided in this effort by our recent employment of color

spectrograms using ISEE-3 channel data, and we will employ these plots to try to identify changes in the character of the upstream emissions and further define the controlling parameters for the presence of upstream ions.

Magnetosheath

We will further explore the persistence of magnetosheath emissions far downstream and document the change in wave amplitude with distance downstream. By exploring the rate at which the emission decays will help us to identify the sources of free energy for the mode, or determine if this wave activity is even the result of a conventional plasma instability. There also exist cases of an absence of waves immediately downstream of some flank shocks, which we suspect might result from a peculiar magnetic field geometry that isolates the magnetosheath from the wave free energy source. We will also document the persistence of plasma oscillations downstream and investigate possible mechanisms for creating these waves.

References

Fuselier, S. A., and D. A. Gurnett, Short wavelength ion waves upstream of the Earth's bow shock, *J. Geophys. Res., 89,* 91, 1984.

Gallagher, D. L., Short-wavelength electrostatic waves in the Earth's magnetosheath, *J. Geophys. Res., 90,* 1435, 1985.

Greenstadt, E. W., F. V. Coroniti, S. L. Moses, B. T. Tsurutani, N. Omidi, K. B. Quest, and D. Krauss-Varban, Weak, quasiparallel profiles of Earth's bow shock: A comparison between numerical simulations and ISEE 3 observations on the far flank, *Geophys. Res. Lett., 18*, 2301-2304, 1991.

Greenstadt, E. W., F. V. Coroniti, S. L. Moses, and E. J. Smith, Plasma wave profiles of Earth's bow shock at low Mach numbers: ISEE 3 observations on the far flank, *J. Geophys. Res., 97,* 10,841, 1992.

Technical Presentations

Greenstadt, E. W., S. L. Moses, F. V. Coroniti, and E. J. Smith, Plasma wave activity outside the far flanks of the Earth's bow shock, presented at the Spring Meeting of AGU, Montreal, Canada, May, 1992.

Moses, S. L., E. W. Greenstadt, F. V. Coroniti, and E. J. Smith, Plasma wave activity in the deep magnetosheath inside the far flanks of Earth's bow shock, submitted for presentation at the Spring Meeting of AGU, Montreal, Canada, May, 1992.

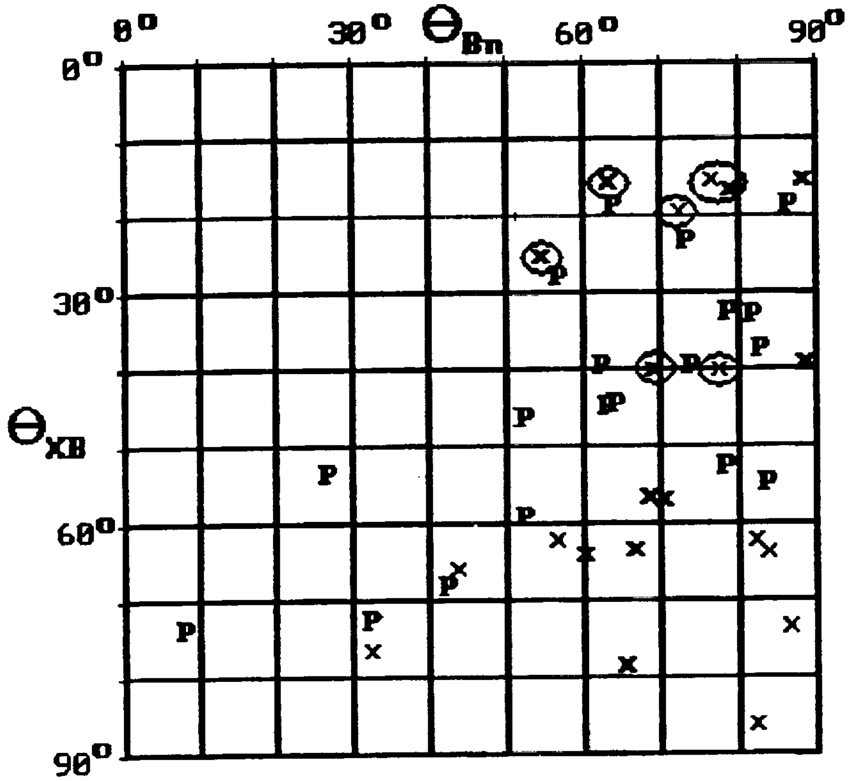

Figure 1. Scatter diagram of the locations of pw feet on the ϑ_{Bn}-ϑ_{BX} plane. X's indicate shocks without plasma wave precursors, while p's indicate the presence of waves upstream. Circled cases are anomalies that are being currently investigated.

MAGNTOSHEATH WAVES AT HIGH TIME RESOLUTION

DAY 266 1983

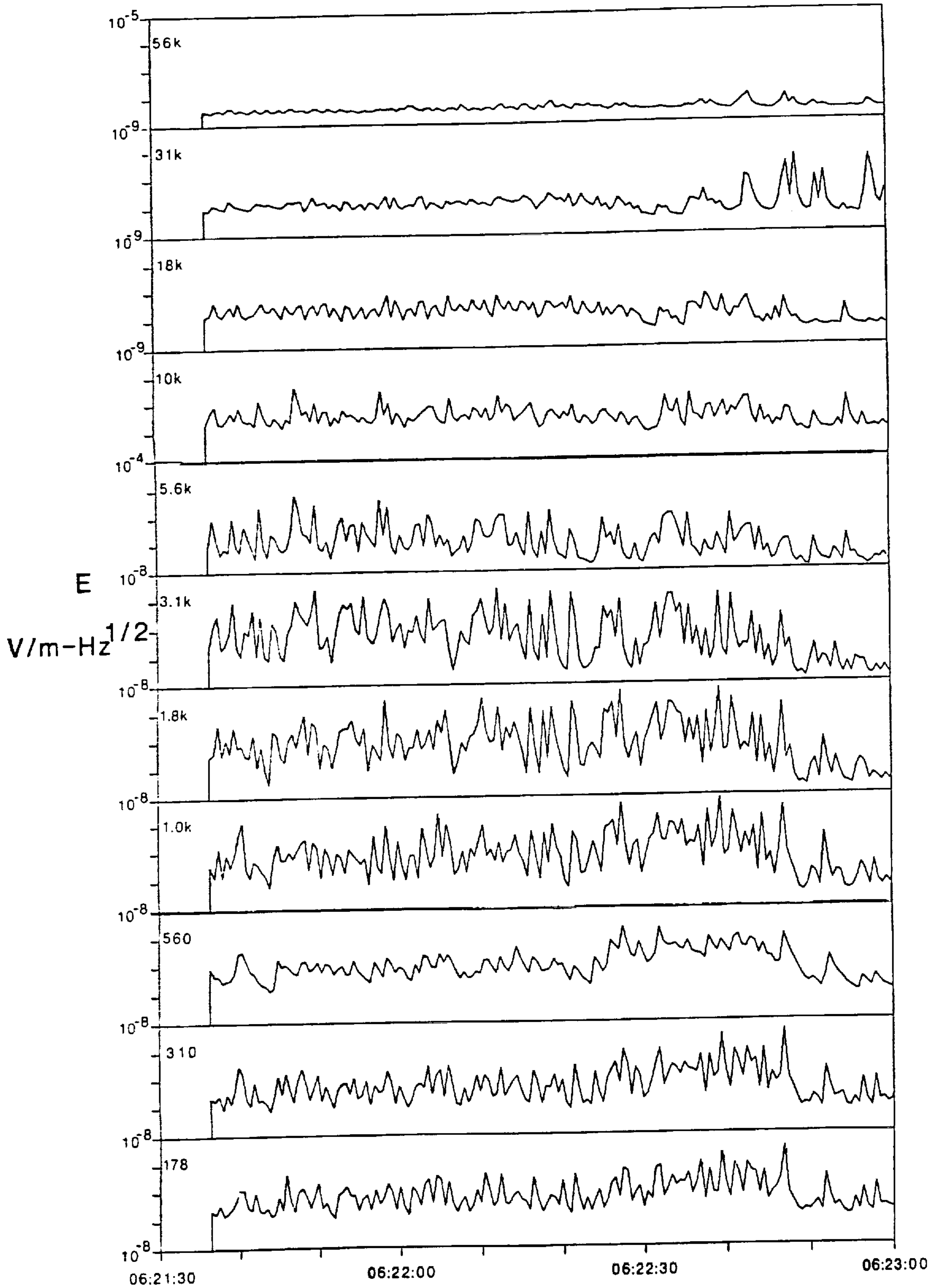

Figure 2. High resolution plasma wave data downstream from a low Mach number shock on the far flanks.